Comparison of Production Costs and Benefits of Horticultural Crops and Field Crops under Irrigation in North Wollo

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Abstract

Maximization of returns and production of marketable surplus from irrigation scheme, which are constructed with huge capital resources, are vital for transformation of the traditional agriculture and thereby agro-industrialization. The objective of this paper is to compare production costs and benefits of horticultural crops versus cereal crops under irrigation in North Wollo at Golina, Gimbora and Aela irrigation schemes. Data was collected from 112 irrigation users and group discussion with beneficiaries. The results show that the area coverage of cereals accounts 90% and 75% during the wet and dry season, respectively. Under the current production practice, the average yields of cereals and vegetables are 12 and 53 in wet season and 14 and 66 in dry season in quintal per hectare, respectively. The gross margin of horticultural crops per hectare provides more than three folds at the current crop budget. The result indicated that the improved crop budget with research results provide more than ten folds gross margin per hectare of irrigated land for horticultural crops than the current situation. This result indicated that there is wide gap between potential of irrigation and its actual utilization. The main reasons are minimal use of improved seed varieties and modern inputs, low managerial and technical skill of horticultural crop growers, weak and fragmented link between public and private support services. To transform the existing subsistence production system under irrigation urgent need to develop management of business entrepreneurship and production methods of horticultural crop growers, utilize recommended application rate of modern inputs, and provide coordinated and integrated support services. This could facilitate rural innovation so that small scale rural growers can find and manage markets, access value adding technologies, achieve improved links with other actors, and organize effective support services.

Key words: *horticultural crops, irrigation scheme, gross margin, crop budget*

1. Introduction

Agricultural production in northeast Ethiopia is characterized by very diverse production system, meager resource base and low productivity. The problems of low productivity thereby low income become aggravated over years because of diverse biophysical and socio-economical constraints. According to classical economics principles productivity or income can be increased either through introduction of improved technologies and/or through efficient allocation of resources. With regard to introduction of improved technologies different interventions are now being developed and introduced to transform the existing low productive agriculture to a more intensified agriculture particularly in lowlands of Wollo.

As a major alternative to alleviate the problem of moisture deficit in northeast Ethiopia, installation of irrigation scheme is widely practiced since long years ago. So far about 1821 hectares of land have been developed for irrigation in north Wollo by different organizations. Farmers grow several traditional food and cash crops (up to 30) using these irrigated lands. In some cases cereals are dominantly produced that may reduce the return from such irrigated lands. Extension people recurrently requested the research to look for recommendation on crop enterprise mix for irrigated areas.

Since irrigated lands are the scarcest capital resource, farmers are required to utilize it to the maximum. The return from a unit of irrigated land, therefore, highly determines the level of food security at the household level and the level of total production at the regional level. Though some researchers stated that farmers select most efficient enterprises considering their multiple objectives, there are enough evidences for the possibility of increasing farmers' income through re-choice of crop enterprises. The practical observation in low lands of Wollo where small and medium scale irrigation system are installed shows that farmers grow cereal food crops which may have lower return per unit irrigated land as compared to horticultural cash crops. Moreover, farmers' choice may be restricted by external factors that can be potentially altered through simple interventions.

Depending on the objectives and type of farms crop choice can be made based on natural or social or economical factors. Economic feasibility of the crops shall be the most important factors that need to be considered while crop choice is made for irrigated small-scale farms due to two reasons. Firstly the natural risk is less and the investment cost is high that leads to maximization of reruns to be a major objective. Secondly unless marketable surplus starts to produce from such farms, agricultural transformation thereby agro-industrialization will not be possible.

Hence, crop choice study becomes an important area of research to make the irrigation production system more economically efficient.

Objectives:

1. To compare production costs, benefits and market opportunities of irrigated crops
2. To determine the crop mix for irrigation and compare with the existing cropping pattern in terms of resource use and income for farmers

2. Literature Review

Crop enterprise choice is one method of increasing farm efficiency. Colman and Young (1989) divide efficiency in to three: technical efficiency, allocative efficiency and economic efficiency. Crop choice in any case can be taken as allocate efficiency.

With regard to allocative efficiency, classical Economic principles states that resources are in reality limited that have to be allocated among competing uses or enterprises. Colman and Young (1989) state the concern of production theory towards product combination as "as with all branches of economics, production economics is concerned with the allocation of scarce resources to alternative uses. In production theory the main choices centre upon what to produce (which product or combination of products), how much to produce…"

The same authors specify the relationship of competent enterprises on limited resources as "Choosing to allocate resources in one way rules out other choices. The opportunity cost of a decision is the value of the best alternative choice, which is foregone as a result of that decision. In the context of the production possibility frontier the decision to produce more maize involves switching resources from wheat production and therefore sacrificing wheat out put."

There are arguments with regard to the efficiency level of different farms at different levels in developed and developing countries. Shultz (1964) and others have argued that, given their access to resources, peasant farmers combine inputs in a manner, which yields maximum profits; ‘peasants are poor but efficient’.

This view has been influential in the design of development strategies and has promoted, notably in 1970s, a number of empirical investigators of farmers’ efficiency in developing countries (Colman and Young, 1989). The authors provide empirical evidences from India by different investigators. All shows that small farms are more efficient than large farmers. And hence, no need of reallocation of resources to competing resources.

However, there are enough empirical studies and practical problems which all suggest the need for conducting crop enterprise choice particularly in our country.

Debebe Habtewold had conducted almost similar study in Awassa-zuria to see the impact of tobacco growing on farmers’ allocative efficiency. He uses linear programming model to develop optimum farm plans under current level of technology and improved technology. He had found that there is a possibility of improving farm income and resource use through efficient resource allocation or enterprise choice. His final conclusion was stated as “farm income and resource use on farms in Awassa-zuria districts could be improved through optimum allocation of resources and adopting better agricultural technologies.”

Being aware of the problems of enterprise choice in Ethiopia, the Ethiopian Agricultural Research organization Socio-economic research strategic document explicitly recommends crop choice study as “farmers make production decision in a complex environment. Both natural circumstances and economic environment influence the selection of enterprises and level of input use. Optimal mix of commodities and optimal combination of resources are key issues in any production problem, resource bases, resource utilization, enterprise choice and profitability of the different enterprises will be studied.”

A farming system study made in the lowlands of Wollo in 1999 (Kobo) by Sirinka agricultural research center also suggest the need for study on crop enterprises choice for irrigated low land areas.

Profitability comparison of crops was studied in central rift valley by Aleligne et al (1992) in 1990/91 and 1991/92 cropping season. The major objective of the study was to test the profitability of potato as compared to others and concluded that although potato is labour intensive it is the second, next to teff, in terms of net return to land and management under small farm condition. Onion and tomato production on the banks of the Awash River has become the interest of many investors. Production of these crops in the dry season can generate a higher net return per hectare.

3. Methodology

3.1. The study area

Golina, Gimbora and Girana (Burka) irrigation scheme were selected purposively. Girana is located in Habru district of Aela by SEARAR in 1993 with a command area of 137 ha for 597 irrigation users. Golina is located in Kobo at Aradom Kebele started by EWCA in 1985 and completed by SEARAR in 1995 with a command area of 400 ha for 1300 farmers. Gimbora located in Gubalafto at Gedober kebele constructed by SEARAR in 1998 with a command area of 200 ha for 781 farmers.

3.2. Data sources and methods

Data were collected from primary and secondary sources. Primary data were collected from farmer fields, farmer's interview using structured questionnaire. Checklists were also used to conduct group discussion and key informant survey on markets challenges and opportunities. Price data were collected from selected markets monthly for three years. Secondary data were collected from Agriculture and Rural Development Office and cooperative desks from the respective districts.

3.3. Sample size and sampling technique

Irrigation sites and markets were selected purposively for undertaking the study. Price of crops and livestock produce on selected market was collected for all types disposed on markets. Farmers interview were made for 112 respondents, which are selected by taking irrigation user list from Yewuha abat and/or irrigation users association office. The 135 samples were drawn randomly from the list using randomization technique. The rest were not interviewed for their absence in the area, elderness and incapable to provide adequate information.

Table 1 number of population and sample in the selected irrigation scheme

Irrigation scheme	Command area (ha)	Number of users	Number of sample interviewed
Golina (Aradom)	400	1300	56
Gimbora (Ala)	200	781	32
Girana (Burka)	137	597	24
Total	737	1678	112

3.4. Analytical technique

Data were analysed using descriptive spastics, enterprise budgeting technique and linear programming model.

3.4.1 Enterprise budgeting technique

Partial crop budget was developed for existing and improved cropping practice by computing production cost, benefits for each irrigation scheme. Markets were assessed for crops grown and to be grown in both irrigation sites.

3.4.2. Linear programming (LP) Model

LP was used to determine the optimal cropping pattern and resource use pattern for average farm household under each irrigation scheme. The objective function of irrigation users was specified to maximize gross margin of the selected crops. Problems in agricultural production include questions of each crop enterprises should be combined, what methods of production should be employed, and which size of the farm is optimal (Heady, 1954). Decisions concerning agricultural problems are analyzed with the help of quantitative methods. Each farm household is confronted with complex decision problems of multi-input and multi-product farming situations. Mathematical programming models have been used to solve various decision problems of the different farm household on allocation of crops on the given farm lands, allocation of various inputs to the production of crops products i.e., how much of crops products should be produced. Given the supplies of resources, productivity's of crops activities how much of scarce resources should be borrowed, what are the gaps between, supply or demands of inputs, main products or by-products of crops activities, etc.

The Basic Structure of LP Model

In the matrix form the general linear programming model is specified as

Maximize: Z = C\`X (1) Objective function

Subject to the programming restrictions:

$AX \leq B$ ------(2) Constrained Equation

$X \geq 0$------- (3) Non-negativity Equation

Where:

C\` is transpose vector of prices or gross margin of crop activities

A is a matrix of input-output coefficients

B is a vector of input supplies

X stands for activities considered in the model

Z is the objective value to be maximized

The objective of the farmer is maximization of farm gross margins and this is termed as objective function in the first equation of the LP model. The second equation of the LP model specifies the demand and supply balances with regard to different inputs or constraints. The left hand side of the second equation indicates the demand for inputs, but on its right hand side (RHS), are shown the input supplies i.e., with regard to availability of different kinds of lands, and other inputs in different seasons with the farmers. Thus A is a matrix of inputs, denoting the i^{th} input required per unit of the j^{th} crop activity. Here j denotes columns, while i indicates rows in the A matrix. This means that the A matrix comprises of a_{ij} coefficients, i.e., i^{th} input coefficient that is required to produce one unit of the crop activity.

The demands and supplies for inputs can be restated in terms of matrices as represented below.

$$\begin{bmatrix} a_1\ x_1 + a_{12}x_2 + --- + a_{1n}x_n \\ a_{21}x_1 + a_{22}x_2 + --- + a_{2n}x_n \\ . \\ . \\ . \\ a_{m1}x_1 + a_{m2}x_2 + --- + a_{mn}x_n \end{bmatrix} \leq \begin{bmatrix} b_1 \\ b_2 \\ . \\ . \\ . \\ bi \end{bmatrix} \qquad \text{--- (4)}$$

Here inputs in rows are specified as i = 1 to m constraints

Activities in columns are indicated as j = 1 to n activities.

$b_{1,}\ b_2$ ....b_i are input supplies, i = 1 to m constraints

$X_1\ X_{2\ ....}$ Xj are crop activities. j = 1 to n activities

The imbalances between demands and supplies of inputs constraints are indicated with inequality signs (i.e. $\leq or \geq$) or equal to signs (=). The resource constraints or demand-supply balances between products of crops activities are indicated with the following signs. For example, maximum input constraints are specified as

$\Sigma\Sigma a_{ij}x_j \leq b_i$, for i = 1 to m inputs (5)

This constraint would mean that sum of the values of the input i^{th} on the left hand side of equation (5) [$\Sigma\Sigma a_{ij}x_j$] cannot exceed the value of its supply on the right hand side [b_I]. Hence this constraint is termed as maximum constraint for i^{th} input. The third equation denotes the non-negativity values of the enterprises considered in the LP model.

The Objective Function

The objective or goal of the grower is maximization of farm gross margin from the suitable crops activities, given his farm resources such as land, labour and capital inputs. The gross margins are the income surpluses over variable costs. All the items included in the objective function represent monetary values. The prices considered in the model were the average market prices for the year 2004/2005. Variable costs were calculated on a per unit basis for crop (per ha) activities.

Crop Production Activities

The various activities considered in the LP model were crop production in wet and dry season under irrigation. Purchasing of labour and borrowing of fund during limitation was considered under activities. Adequate care was taken in choosing the relevant irrigation activities of the representative farms in question, particularly for reflecting realistic farming conditions and for optimizing farm gross margins and resource use. The study is primarily interested in analysing the impact of potential irrigation crop practices as well as the impact of the existing crop practices on the whole farm income through the different alternative farm plans.

Average values were computed for inputs (seed, fertilizer, human labour, oxen labour and working capital), yields and gross margins. In each irrigation scheme with the difference in enterprise selection of farm household, the differences in input use were considered and used. Moreover, the use of inputs (fertilizers, improved seeds) based on the recommendation rate of researchers was considered in modelling the improved technology for some crops.

Borrowing Activity

Borrowing activity provides the farmers with the option of obtaining working capital to purchase improved technologies. It also helps to purchase other inputs under the assumption that farmers could not afford. Therefore, borrowed fund was incorporated in the model so that farmers would use improved practices based on their need and resource endowments.

The Constraints

The Basic Resource Constraints

The major resource constraints identified in both schemes included land, draft oxen, working capital, and family labour. The supply of these resources though dependent on the holding of each farm household acted as a constraint to optimize farm plan for different areas of the site.

Land Constraint

The farm family is using all irrigable land available in wet and dry season. Some farmers are operated on a share-cropping basis. The terms and conditions of the share-cropping system are decided upon prior to the cultivation of land by the two parties. Land allocation per season is defined as a separate row in the farm model as wet and dry crop land.

The smallholders require that a certain minimum percentage of their available land be allotted to cereal crops in the study area. This requirement in the land constraint is specified as

$$\sum x_{\mathbf{j}} \leq b_L$$

Where Xj is level of the jth crop activity

bL is the available land area for jth crop activity

Under crop activities land restraint row coefficient was specified as unity (one), because the unit specified is one hectare. For each farm in both areas, the total available irrigated land size per household was considered in the model. It should be noted that share in crop land was considered for the average farm household. Conversely share out land area was not considered for the farm households as it was not common for our sample respondents.

Labor Constraint

Family Labour

The category of labor is essential in all farm situations. Labour for irrigation is required through out the year. Hence, there is no categorization of labour in the specification of the model.

Algebraically labor restrictions are specified as

$$\Sigma_i \Sigma_j a_{ij}x_j \leq B_i$$

X_j is the level of j^{th} crop activity,

for j = 1 to n activities

i = 1 to m labour types

a_{ij} = coefficient of the i^{th} type of labor required per unit for the j^{th} crop activity.

B_{is} = total i^{th} amount of family labour available

Moreover, hiring in family labor by average farm households was specified in the farm model during scarcity.

Draft Power

Because cropping operations such as land preparation and planting (sowing) are almost exclusively done by using oxen, availability of draft oxen power was taken as one of the major constraints in the irrigation systems.

The mathematical form of the constraint is thus given as:

$$\Sigma_j OX_{ij} X_j \leq TOX$$

Where: Ox_{ij} = i^{th} amount of draft power required per unit of j^{th} activity of crop production

TOX = total i^{th} amount of draft power available. Moreover, hiring in oxen labor by average farm households was specified in the farm model during scarcity.

Working Capital Constraints

Farm households require operating capital for buying inputs such as improved seeds and fertilizers. Local seeds are retained from previous harvest, while labour, fertilizers, and improved seeds are purchased partly on cash and partly on credit basis. Interest (about 18%) is charged on the borrowed capital and is reduced from the gross return. Thus, capital requirements for purchased resources are included in the model and directly constrained.

$\Sigma_j k_j x_j \leq OW_j + BW_j$

Where: k_j = Amount of working capital required per j^{th} activity.

X_j = Level of j^{th} activity.

OW_j = Own working capital available for j^{th} activity.

BW_j = Borrowed working capital required for j^{th} activity.

Maximum Restriction

Maximum production level was imposed to fruits and vegetables based on the market restriction as the average levels they had already been planted. This was done to reflect the farmers' strategy to augment crop land area through demand for fruits and vegetables in the current market.

$Q_{ot} \leq Q_{at}$

Where: Q_{ot} and Q_{at} represent optimum and actual fruits and vegetables production.

This restriction is made for the reason that the optimal production level of fruits and vegetables should not be greater than the actual level.

Minimum Restriction

Minimum production level was imposed to cereals based on the animal feeds requirement as the average levels they had already been planted. This was done to reflect the farmers' strategy to augment crop land area for demand of farmers to make available the animal feed.

$$Q_{at} \geq Q_{ot}$$

Where: Q_{ot} and Q_{at} represent optimum and actual cereals production.

This restriction is made for the reason that the optimal production level of cereals should not be less than the existing demand level.

Estimation of Technical Coefficients

Estimating the appropriate input-output coefficients for smallholders is problematic as there are no farm records. Data collection heavily depends on memory and understanding of farmers and the technical advisors working in the area. Earlier study reports were also referred to whenever available. All the information that describes the husbandry of each crop activity was estimated according to the requirement of each operation throughout the memory of farmers. The data refer to the number of units of each of the resources required per unit of activity. Accordingly, the average cropped area and the average labour available were calculated for the average of farming household after converting the female and children labour into their respective man-equivalents. The per hectare yields of annual crops were determined based on the survey results. Technical coefficients for different activities were computed by taking the average of the values of the variables for the different schemes. To derive the coefficients for improved crop production activities, data from on farm research results and other secondary sources were used.

4. Results and Discussion

4.1. Crop production system under irrigation
4.1.1 Crop grown

The major crops grown in Golina for the year 2003/04 in wet season are 52.6% teff, 24.2 % sorghum, 7% pepper, 5.3 % maize, 4.4 % onion, 4.7 % chickpea, and 1.4 % tomato. During dry season the proportion of area covered by teff, onion, tomato, pepper, and maize are 41.2%, 25.3%, 10.3%, 15.4%, and 6.8%, respectively.

In Gimbora irrigation scheme, teff and potato cover more than 71% of the area in dry season. In wet season, sorghum and teff cover 84% of the area. In Girana irrigation scheme teff and onion cover 95% of the area in dry season. Teff and sorghum cover 90% of the irrigated area during wet season (table)

From all irrigation schemes it was observed that teff is the major crops grown both during dry and wet season. The reason behind for the prior selection of farmers indicated that the straw of teff could be used for animal feed. Second, the market demand of vegetable crops (onion, potato, tomato) is highly fluctuating and results in to low price and some times dumping in the market.

Table 2 the type of crop, percentage of crop grown in dry season under different irrigation schemes

	Golina		Gimbora		Girana		Total	
Type of crop	% farmers(1300)	%area (400ha)	% farmers (781)	%area (200ha)	% farmers (597)	%area (137)	% farmers	%area
teff	30.3	41.2	37.3	42.5	31.3	37.8	32.8	41.1
onion	28.3	26.3	16.9	12.2	62.5	57.4	27.6	26.6
tomato	15.2	10.3	5.1	2.2	0.0	0.0	10.3	5.9
pepper	20.2	15.4	10.2	2.6	6.3	4.8	15.5	9.4
potato	0.0	0.0	27.1	28.9	0.0	0.0	9.2	9.7
maize	6.1	6.8	3.4	11.5	0.0	0.0	4.6	7.3

Table 3 the type of crop, percentage of crop grown in wet season under different irrigation schemes

	Golina		Gimbora		Girana		Total	
	%farmers (1300)	%area (400ha)	% farmers (781)	%area (200ha)	%farmers (597)	%area (137ha)	%farmers	%area
teff	34.42	52.64	29.90	34.70	45.45	52.90	34.58	47.48
sorghum	22.73	24.21	34.02	49.63	38.64	37.09	28.81	34.82
pepper	11.04	7.02	7.22	3.94	0.00	0.00	8.14	4.39
onion	9.09	4.42	3.09	0.60	11.36	7.90	7.46	4.07
chickpea	7.79	4.68	9.28	4.29	2.27	1.58	7.46	3.95
maize	9.09	5.28	8.25	1.76	2.27	0.53	7.80	3.22
tomato	4.55	1.40	1.03	0.23	0.00	0.00	2.71	0.63
barley	1.30	0.36	0.00	0.00	0.00	0.00	0.68	0.18
potato	0.00	0.00	7.22	4.86	0.00	0.00	2.37	1.27

4.1.2. Land tenure under irrigation

Land tenure arrangement indicated that 63 farmers cultivate their farm land by their own, 34 farmers cultivate their own farm and share in land, 4 farmers cultivate through share in land and 3 farmers collect produce through share out their land.

Table 4 Total cultivated and irrigated land for irrigation users

	Total cultivated land (ha)				irrigated area (ha)			
	own	share in	share out	total	own	share in	share out	total
count	109	55	6	110	99	39	4	105
average	0.934	0.586	0.420	1.242	0.344	0.335	0.271	0.460
sum	101.8	32.3	2.5	136.6	34.1	13.1	1.1	48.3
min	0.125	0.063	0.063	0.188	0.000	0.063	0.063	0.010
max	3.625	1.750	0.750	4.781	1.250	1.031	0.750	1.500

Table 5 land tenure arrangement under irrigation

Scheme	variables	own area	share in area	share out area	total
Golina	number of users	47	19	4	52
	average holding	0.36	0.35	0.27	0.47
	min holding	0.06	0.13	0.06	0.13
	max holding	1.06	1.03	0.75	1.38
Gimbora	number of users	31	8		32
	average holding	0.37	0.21		0.41
	min holding	0.03	0.06		0.03
	max holding	1.25	0.50		1.25
Burka/Girana	number of users	18	12		21
	average holding	0.32	0.40		0.51
	min holding	0	0.125		0.01
	max holding	1	1		1.5
Total	number of users	96	39	4	105
	average holding	0.344	0.335	0.271	0.46
	max holding	1.25	1.031	0.75	1.5

4.1.3. Input use

Irrigation users are expected to utilize the land to its maximum yield by using improved crop technologies from external sources. In both schemes most farmers are not using external inputs for boosting the production and productivity of crops grown under irrigation. The result indicated that farmers using fertilizer, pesticide, improved seed and hired lab are 19.6%, 24.11%, 33.9%, and 37.5%, respectively. This implied that the potential of irrigation is under utilized with the traditional production system.

Farmers who are using improved technologies are not even applied the recommended packages. Hence, productivity of crops varies with the level and intensity of utilizing external inputs.

4.1.4 Crop production and productivity

It was revealed that the production and productivity of crops per hectare varies with the use of inputs and better agronomic practices. Those farmers who use improved seed, fertilizer and chemical obtained better yield than who do not use. The yield of crops varies across farmers with in each irrigation scheme at the same season. The minimum, most frequent and maximum yield of crops grown under irrigation was estimated for each irrigation scheme at each season (Table 6 and 7). The result depicted that the most frequent yield of teff, sorghum, chick pea and maize are 11, 11, 10 and 19 in quintal per hectare during wet season on the average in the area. The most frequent yield of pepper, onion, tomato and potato are 17, 53, 67 and 70 in quintal per hectare during wet season on the average in the area.

The most frequent yield of teff, chick pea and maize are 10 and 18 in quintal per hectare during dry season. The most frequent yield of pepper, onion, tomato and potato are 33, 42, 130 and 51 in quintal per hectare during dry season.

Table 6 Productivity of crops in wet season (quintal per ha)

Type of crop		Golina	Gimbora	Girana	Total
teff	minimum	8	7	6	7
	mode	9	10	12	11
	maximum	12	12	14	13
sorghum	minimum	8	7	6	7
	mode	13	12	13	11
	maximum	19	16	15	16
pepper	minimum	7	11		9
	mode	16	19		17
	maximum	35	26		31
onion	minimum	17	44	32	33
	mode	38	62	48	53
	maximum	58	100	80	86
Chick pea	minimum	5	6		5
	mode	9	11		10
	maximum	18	17		18
maize	minimum	31	14	8	19
	mode	29	18	8	19
	maximum	71	28	8	40
tomato	minimum	56	64		59
	mode	59	80		67
	maximum	90	128		104
potato	minimum		45		45
	mode		70		70
	maximum		82		82

Table 7 Crop productivity in dry season (quintal per ha)

Type of crop		Golina	Gimbora	Girana	Total
teff	minimum	4	8	5	6
	mode	14	11	7	10
	maximum	21	21	12	17
onion	minimum	9	16	21	16
	mode	48	32	38	42
	maximum	50	56	52	54
tomato	minimum	36	126		81
	mode	82	189		130
	maximum	108	253		180
pepper	minimum	11	16	24	14
	mode	31	42	32	33
	maximum	32	68	40	38
potato	minimum		40		40
	mode		51		51
	maximum		65		65
maize	minimum	11	8		10
	mode	20	15		18
	maximum	26	20		23

4.2. Crop budget

The technique is designed to quantify the inputs employed and output produced for particular enterprise. Farmers existing crop activities, resource use and production were analysed using tangible costs and benefit to compare different enterprise.

4.2.1. Current crop budget

Farmers use the irrigation during wet and dry season. Crop budget for existing production system was computed for dry and wet season for the major crops grown in the irrigation scheme. The result indicated that vegetables (tomato and onion) are producing better gross margin per hectare than cereals (teff, and sorghum) and pulse (chick pea) in both dry and wet season. Farmers select the plant based mainly on the market restriction on vegetables and animal feed on cereals. Tomato and onion provide better gross margin than cereals in the irrigation practice during wet season (Table 8 and 9).

Table 8 Crop Budget for existing situation in wet season Birr/Ha

meher	meas't	Unit	teff	sorghum	pepper	maize	tomato	onion	chickpea	potato
cost										
human lab	**Qty**	MD	103	79	152	81	180	211	66	120
	Price	Birr/MD	5	5	5	5	5	5.0	5	5
	Value	Birr	515	395	760	405	900	1055	330	600
animal lab	**Qty**	OD	18	22	20	22	20	21	19	22
	Price	Birr/OD	25	25	25	25	25	25.0	25	25
	Value	Birr	450	550	500	550	500	525	475	550
seed	**Qty**	Kg	36	14	3	26	1	3	81	1082
	Price	Birr/Kg	2.50	2.00	15	8	162	189.0	2.7	1.2
	Value	Birr	90	28	46	208	162	567	221	1298
chemical rate	**Qty**	Litre						4.00		
	Price	Birr/Litre						75		
	Value	Birr						300		
Total cost			**1055**	**973**	**1306**	**1163**	**1562**	**2447**	**1026**	**2448**
Return										
grain yield	**Qty**	Kg	1145	1466	2079	2489	6780	5074	952	7078
	Price	Birr/Kg	2.78	1.52	2.04	1.54	0.84	1.3	2.56	0.52
	Value	Birr	3183	2225	4241	3841	5695	6495	2437	3708
straw yield	**Qty**	Kg	1624	2590		4499			1616	
	Price	Birr/Kg	0.265	0.07		0.05			0.03	
	Value	Birr	430	168		212			44	
Gross return		Birr	3613	**2393**	**4241**	**4054**	**5695**	**6495**	**2481**	**3708**
Gross margin		Birr	2558	**1420**	**2935**	**2891**	**4133**	**4048**	**1455**	**1259**

Table 9 Crop Budget for existing situation in dry season Birr/Ha

area(ha)	meas't	unit	teff	onion	pepper	maize	tomato	potato
cost								
human lab	Qty	MD	103	211.0	152.00	81.0	166.0	92.0
	Price	Birr/MD	5	5.0	5	5.0	5.0	5.0
	Value	Birr	515	1055	760	405	830	460
animal lab	Qty	OD	18	21.0	20.00	16.0	20.0	20.0
	Price	Birr/OD	25	25.0	25	25.0	25.0	25.0
	Value	Birr	450	525	500	400	500	500
seed rate	Qty	Kg	36	3.0	3	22.0	2.0	900.0
	Price	Birr/Kg	2.50	189.0	15	1.25	92.0	1.0
	Value	Birr	90	567	46	28	184	900
urea rate	Qty	Qt		0.9				
	Price	Birr/Qt		200.0				
	Value	Birr		184				
chemical rate	Qty	Litre		2.7				
	Price	Birr/Litre		80.0				
	Value	Birr		214				
Total cost			**1055**	**2545**	**1306**	**833**	**1514**	**1860**
Return								
grain yield	Qty	Kg	1145	5074.0	2560.0	2067.0	13000	5150.0
	Price	Birr/Kg	2.78	1.3	2.09	1.7	0.42	0.70
	Value	Birr	3183	6495	5350	3431	5460	3605
straw yield	Qty	Kg	1624			2952.9		
	Price	Birr/Kg	0.265			0.025		
	Value	Birr	430			74		
Gross return		Birr	3613	**6495**	**5350**	**3505**	**5460**	**3605**
Gross margin		Birr	2558	**3950**	**4044**	**2673**	**3946**	**1745**

4.2.2. Improved crop budget

The partial crop budget for improved practice was developed to quantify the inputs employed and output produced for each crop enterprise. Crop budget computed for improved practice using research results in the current production and productivity of every resource employed for irrigation provide more than two folds gross margin per hectare particularly for fruits and vegetables growers in both wet and dry season (Table 10 and 11).

The result indicated that if irrigation users have been applied the recommended improved practice for cereals and vegetables with appropriate production methods, the yield and gross margin of crops would increase more than two folds. These results remind as to question our self, what are the factors contributing for poor achievement of yield potential? This demands to think beyond increased productivity of crops. This paper attempts to address how the support services are organized and coordinated for achieving better management of irrigation water.

Table 10 Crop Budget for improved practice (Wet season), Birr/Ha

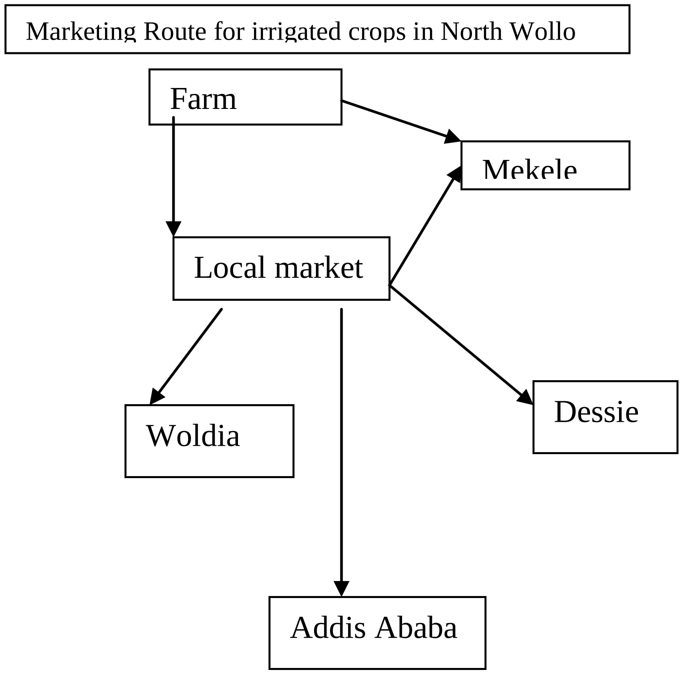
			ground nut	sesame	chick pea	haricot bean	cow pea	teff	maize wet	sorghum wet
No	Items	Unit								
1	**Cost**									
1.1	Labour	MD	84	84	151.75	151.75	110	123	165	119
	Price	Birr	8	8	8	8	8	8	8	8
	Value	Birr	675	675	1214	1214	880	984	1320	952
1.2	Oxen	OD	8	8	10	10	13	20	16	16
	Price	Birr	30	30	30	30	30	30	30	30
	Value	Birr	240	240	300	300	390	600	480	480
1.3	Seed	Kg	60	5	85	130	30	30	30	10
	Price	Birr	9.5	500	2.45	4.2	3	3.5	8.2	2.4
	Value	Birr	570	2500	208.25	546	90	105	246	24
1.4	Dap	Qt	1	1	1	1		1	1	1
	Price	Birr	275	275	275	275	275	275	275	275
	Value	Birr	275	275	275	275	0	275	275	275
1.5	Urea	Qt	0.5	0.5	0.5	0.5		0.5	0.5	0.5
	Price	Birr	230	230	230	230	230	230	230	230
	Value	Birr	115	115	115	115	0	115	115	115
1.6	Pesticides	lumpsum	94.75	200	62.75	62.75	157.8	126	70.6	157.8
	Total cost		**1970**	**4005**	**2175**	**2513**	**1518**	**2205**	**2507**	**2004**
2	**Return**									
2.1	Crop Yield	Qt	61	15	31	33	21	26	73	53
	Price	Birr	350	600	220	195	280	200	100	120
	Value	Birr	21350	9225	6710	6362	5775	5175	7275	6345
2.2	Straw Yield	Qt						129	364	264
	Price	Birr						5	2	3
	Value	Birr						647	728	793
	Gross Return	**Birr**	**21350**	**9225**	**6710**	**6362**	**5775**	**5822**	**8003**	**7138**
3	**Gross margin**	**Birr**	**19380**	**5220**	**4535**	**3849**	**4257**	**3617**	**5496**	**5134**

Table 11. Crop Budget for improved practice (dry season), Birr/Ha

			papaya	Banana	onion	shallot	tomato	potato	sweat potato	citrus	pepper	maize dry
No	Items	Unit										
1	**Cost**											
1.1	Labour	MD	317	317	280	280	244	168	168	356	253.8	165
	Price	Birr	8	8	8	8	8	8	8	8	8	8
	Value	Birr	2534	2534	2240	2240	1950	1344	1344	2845	2030	1320
1.2	Oxen	OD	11	11	22	22	13	22	22	11	13	16
	Price	Birr	30	30	30	30	30	30	30	30	30	30
	Value	Birr	330	330	660	660	390	390	660	330	390	480
1.3	Seed	Kg	2500	2500	4	1400	0.25	1800	33333	800	1	30
	Price	Birr	1	0.5	120	5	318	3	0.1	1	40	8.2
	Value	Birr	312.5	156.25	480	7000	79.5	5400	3333	100	40	246
1.4	Dap	Qt	2	0.5	2	2	2	1.63		0.5	1.5	1
	Price	Birr	275	275	275	275	275	275	275	275	275	275
	Value	Birr	550	137.5	550	550	550	448.25	0	137.5	412.5	275
1.5	Urea	Qt	1	3	0	1.5	1	1.96	0	2	0.5	0.5
	Price	Birr	230	230	230	230	230	230	230	230	230	230
	Value	Birr	230	690	0	345	230	450.8	0	460	115	115
1.6	Pesticides	lumpsum	470	470	205.2	157.8	465.4	150	205.2	470	239.5	70.6
	Total cost		**4427**	**4318**	**4135**	**10953**	**3665**	**8183**	**5543**	**4343**	**3227**	**2507**
2	**Return**											
2.1	Crop Yield	Qt	482	250	302	170	480	239	369	150	28	80
	Price	Birr	150	250	150	130	120	85	50	200	890	100
	Value	Birr	72244	62500	45263	22100	57555	20326	18450	30000	25254	7950
2.2	Straw Yield	Qt										398
	Price	Birr										2
	Value	Birr										795
	Gross Return	**Birr**	**72244**	**62500**	**45263**	**22100**	**57555**	**20326**	**18450**	**30000**	**25254**	**8745**
3	**Gross margin**	**Birr**	**67817**	**58182**	**41127**	**11147**	**53890**	**12143**	**12908**	**25657**	**22027**	**6238**

4.3. Marketing analysis of major vegetable crops grown under irrigation

The major vegetable grown under irrigation in Golina, Gimbora, and Girana are onion, tomato, pepper, and potato. These crops are grown for markets. There are limited numbers of traders who are involved in marketing of products from that farm to dispose to various markets. The major marketing chains for vegetables in the area are described below



Marketing Margin

The marketing margin of different participants in tomato marketing at Woldiya varies with their active involvement and market information. Traders are relatively smaller in number and are sole determinant of the price based on the supply of the produce. The net marketing margin for tomato producers in Golina is 34% at Woldiya market (Table 12). However, the net marketing margin for pepper producers in Golina is 59% at the same market. These indicate that the markets are operating inefficiently and vegetable producers using irrigation are not receiving the appropriate price for their produce.

Table 12 Marketing margin of different actors in the marketing chain at Woldiya market for crops

	Parameters	unit	Tomato	Onion	pepper	potato
A	Farm gate price	Br/Ql	60.00	131.00	173.00	67.00
B	Consumer price	Br/Ql	178.00	235.00	292.00	135.00
C	Variable cost		3.30	3.30	3.30	3.30
	Transport	Br/Ql	2.00	2.00	2.00	2.00
	Loading and unloading	Br/Ql	1.00	1.00	1.00	1.00
	Selection, cleaning and packing	Br/Ql	0.30	0.30	0.30	0.30
D	Absolute total gross marketing margin	Br	118.00	104.00	119.00	68.00
E	Relative total gross marketing margin	%	66.00	44.00	41.00	50.00
F	Net marketing margin for trader	%	64.00	43.00	40.00	48.00
G	Producers share of marketing margin	%	34.00	56.00	59.00	50.00

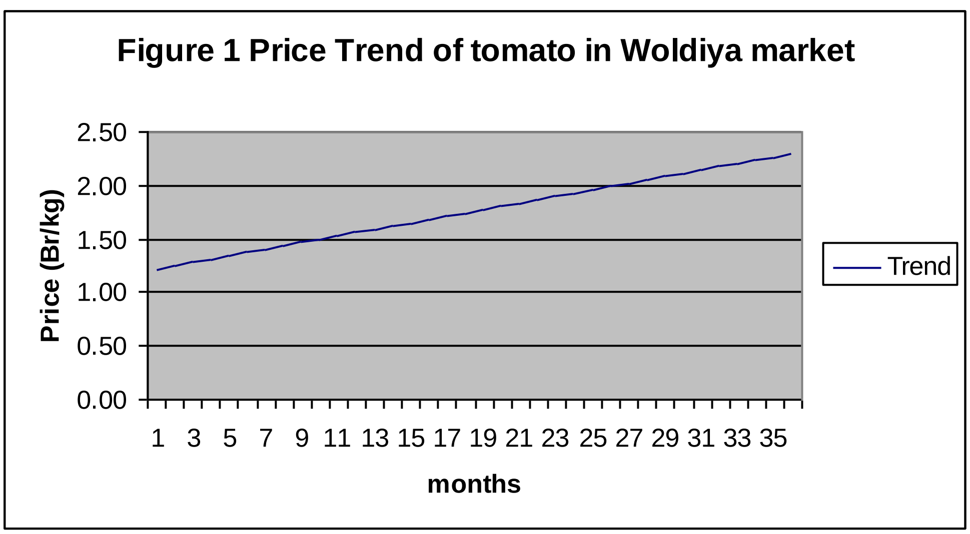
In the same talken, the marketing margin of different participants in tomato and onion marketing at Mekele varies with their active involvement and market information. Traders are smaller in number and are sole determinant of the price based on the supply of the produce. The net marketing margin for tomato producers in Golina is 24% at Mekele market. It is 33% for onion producers at the same market (Table 13). These indicate that the markets are operating more inefficiently even at distant markets. Vegetable producers using irrigation are highly discouraged with inefficient operation of the marketing system.

Table 13 Marketing margin of different actors in the marketing chain at Mekele market for crops

Parameters	unit	Tomato	Onion
Farm gate price	Br/Ql	60	131
Consumer price	Br/Ql	250	400
Variable cost		**16.3**	**16.3**
Transport	Br/Ql	14	14
Loading and unloading	Br/Ql	2	2
Selection, cleaning and packing	Br/Ql	0.3	0.3
Absolute total gross marketing margin	Br	190	269
Relative total gross marketing margin	%	76	67
Net marketing margin for trader	%	69	63
Producers share of marketing margin	%	24	33

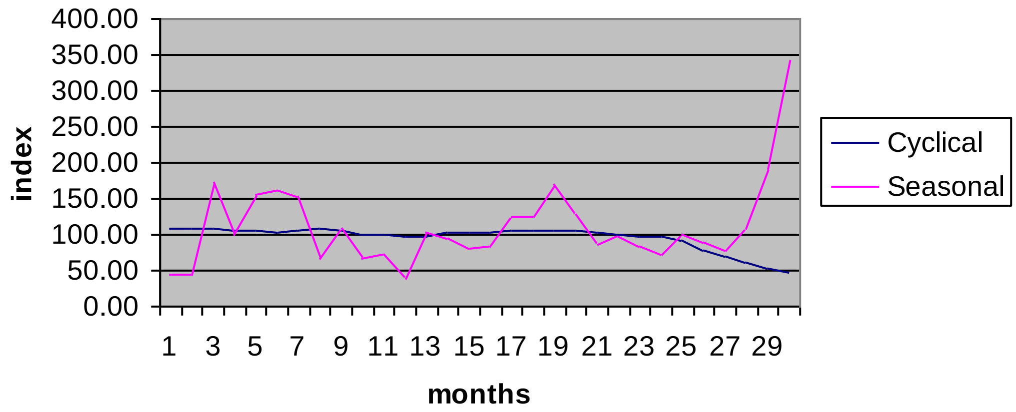
Price Analysis

The price of tomato in Woldiya market depicted an absolute increasing trend overtime. Factors behind trends are inflation, increasing demand and technological progression.



The seasonal component of the price analysis depicted that the price are fluctuating over months with higher rate for tomato. The major factor leading for the variation was the perishability of the product and the seasonality of demand of the product. On the other hand, the cyclical component of price of tomato indicated that there is lagged decision making. Gross real storage returns help estimate the rate of return to storage. The gross real return of storage for tomato is estimated at 157%. On the other hand, the price trend of teff is increasing over time. Factors behind the trend are similar for tomato.

Figure 2 Seasonal and cyclical component of tomato in Woldiya market



The seasonal component of price of teff is less fluctuating than price of tomato. Hence, the price of teff is relatively stable and can be predictable as compared to price of tomato. The gross real return of storage for teff price is estimated at 58% which indicated that there is a possibility to earn a better income by storing teff to sale the price of teff is higher. But the result indicated the rate of return for tomato is much higher than teff due to the perishability of the former. The result implied that there is a possibility to develop the plan for continuous production season.

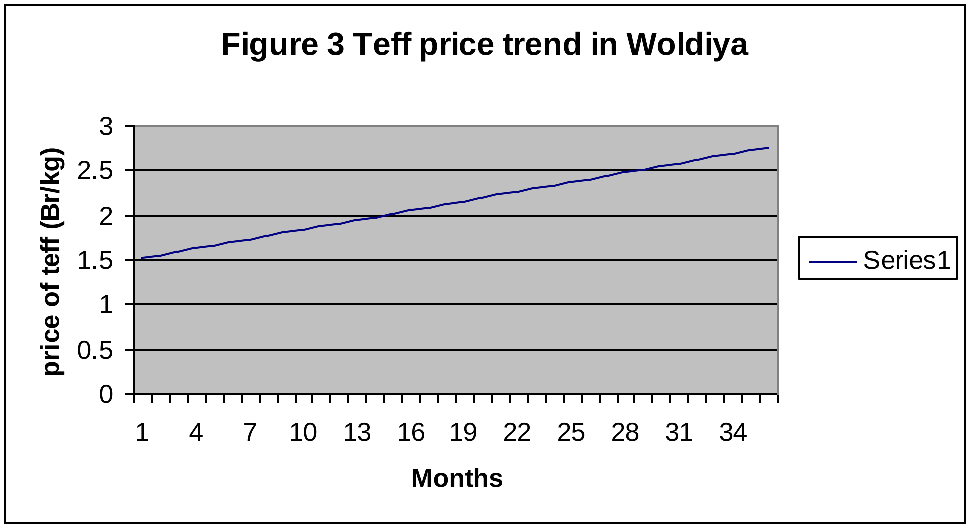


Figure 3 Teff price trend in Woldiya
price of teff (Br/kg)
3
2.5
2
1.5
1
0.5
0
1
4
7
10
13
16
19
22
25
28
31
34
Months
Series1

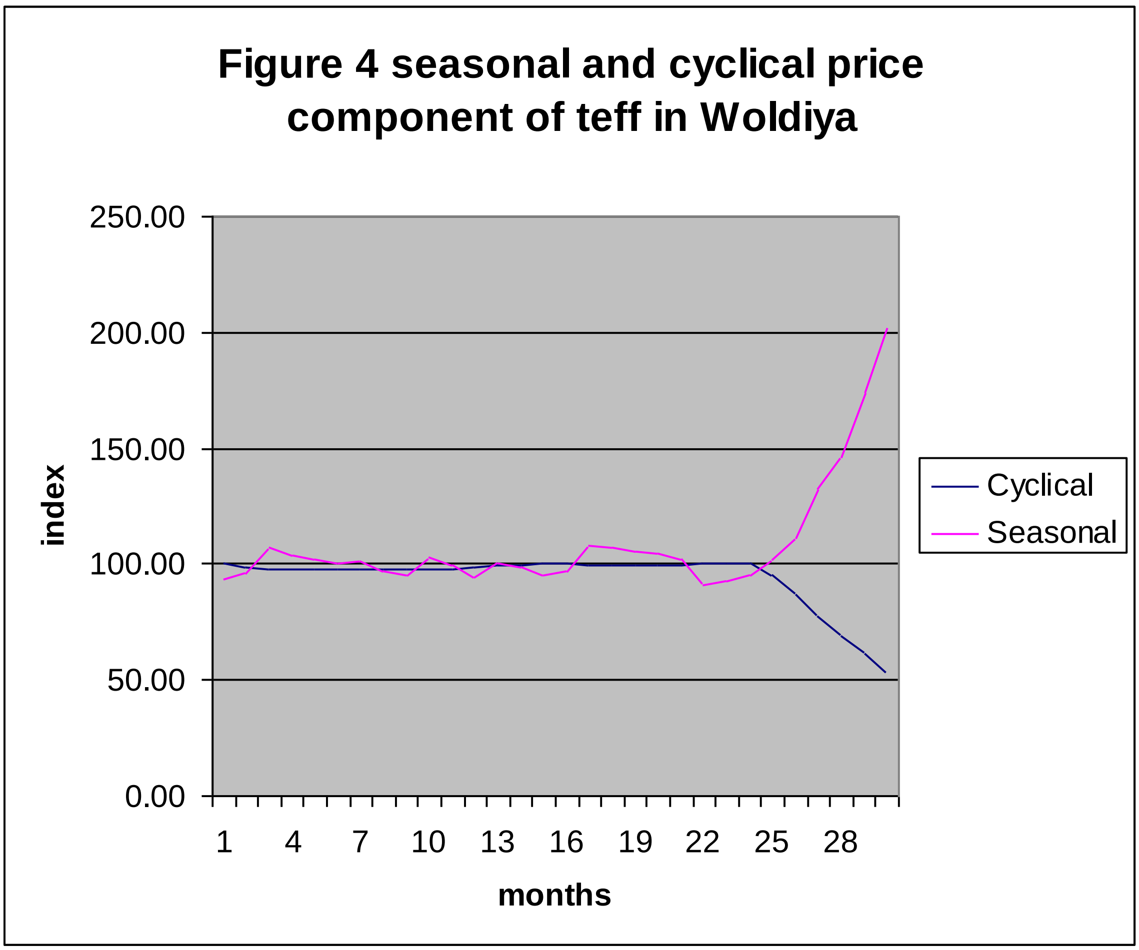


Figure 4 seasonal and cyclical price component of teff in Woldiya
index
250.00
200.00
150.00
100.00
50.00
0.00
1
4
7
10
13
16
19
22
25
28
months
Cyclical
Seasonal

4.4. Optimization Model Results

The model results for an average irrigation user in both schemes favour the use of horticultural crops and external inputs in production pattern, resource use, farm income and farm resource productivity.

4.4.1. Production Patterns

The farm production patterns of the base model along with the farmers' practices indicated that there are deviations between the base model results and the farmers' practices (Table 14). Thus, the table shows that the area under each crop has relatively changed in favour of using horticultural crops.

Table 14 Optimum Production pattern of irrigated crops for Base model results

crop	Base
Teff wet	0.2
Pepper wet	0.05
Tomato wet	0.11
Onion wet	0.1
Teff dry	0.2
Pepper dry	0.11
Tomato dry	0.05
Onion dry	0.1

Table 15 Optimum Production pattern of irrigated crops (alternative model)

Crop	Alternative
Papaya	0.10
banana	0.10
citrus	0.11
Tomato dry	0.15
ground nut wet	0.1
Teff wet	0.11
Maize wet	0.25

4.4.2. Farm income, Resource Productivity and Marginal Value Product of Major Resources

The shadow prices or MVPs of farm resources reflect the opportunity cost under perfect competition situation. It is note worthy that the positive shadow prices of resources depict the nature of limiting resources. The higher the MVP of a resource, the more severe could be the limiting level of that farm resource in question. If MVP is zero it means that the resource is in excess supply over its demand. Moreover, shadow prices for the associated resources indicate how much gross margin change if an additional unit of the resource would could be procured. Therefore, expansion of area by an additional hectare of cultivated area would increase the cash income by the amount of MVP. The analysis of limiting resources in the base model results show that own crop cultivated land is more scarce in both districts than any other farm resource in the model.

Table 16 Farm income, Resource Productivity and Marginal Value Product (MVP)

Particulars	Existing		Base		Alternative	
	wet	dry	wet	dry	wet	dry
1. Farm income						
Gross margin (GM)	1010	1383	1516	1487	3710	26611
2. Productivity						
2.1. Land						
GM/CA	2195.652	3006.522	3296	3233	8065	57850
2.2. Family Labour						
GM/AE	242	332	364	357	890	6382
GM/ME	344	470	516	506	1262	9051
labour employed (MD)	45	63	65	67	63	137
GM/MD	15	21	23	22	59	194
2.3. Working capital (GM/WC)	1.95	1.94	2.2	2.1	3.5	14.6
capital employed (Birr)	519	713	685	693	1066	1827
MVP						
Land			2717	2935	5496	53890

5. Major challenges of irrigation

The majority of the farmers are small-scale holders who still realize low production due to various reasons such as repeated use of low yielding seed varieties. Farmers prioritize the problems as water shortage, irrigated land shortage, low product price, water use conflict, weak technical support, low supply of improved input, canal damage and pest attack, in order of importance

Table 17 Problems and their prioritization for crops grown under irrigation

Type of problems	Frequency	rank
water shortage	73	1
irrigated land shortage	56	2
canal damage	23	7
improved seed shortage	19	8
weak technical support	32	5
low product price	43	3
pest attack	12	9
low supply of improved input	27	6
water use conflict	36	4
labour shortage	8	10
high population density	5	11

Both public and private institutions are weakly linked in providing support for improving the livelihood of the rural producers. Pertinent and promising activities have no yet established institution for addressing the problems of irrigation water management.

Although farmers involved in production using irrigation face a number of constraints, the potential for them to develop still exists as availability of improved technologies for boosting productivity, production of diversity of products, potential for adding value, Government support and improved economic and social status of the rural producers using irrigation scheme.

6. Recommendation

The institutions developed for improving the living standard of the rural communities should have to be capacitated to effectively undertake their tasks. Thereafter they should have to develop integrated approach with public/private partnership to transform the traditional production system. They should have to go near to the community and create continuous discussion and meeting to facilitate rural innovation.

Trainings on business entrepreneurship and production methods are crucial for irrigation users to improve their managerial and technical capacity on managing production and marketing under irrigation. Farmers should have to produce what to sell. They should have not to produce that could not be sold. They should have to produce with informed decision making process. Every partner should have to undertake its task efficiently. The market facilities should have to be developed for efficient marketing system. Market information for rural producers could provide access for better decision.

Institutions that could collect water charges for cost recovery, undertake proper maintenance and repair, protect water pollution are highly beneficial. NGO's are vital for transfer of experience of successful growers from various areas and in providing training for small rural producers.

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Appendices

Figure: Price trend of tomato in North wollo

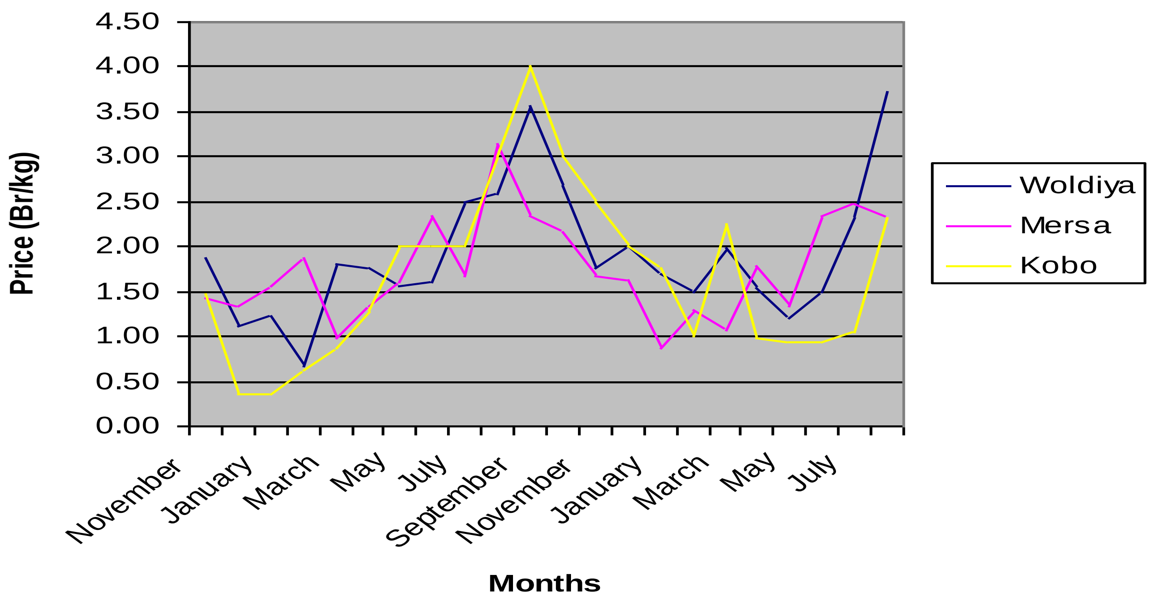

Figure: price of potato in North Wollo

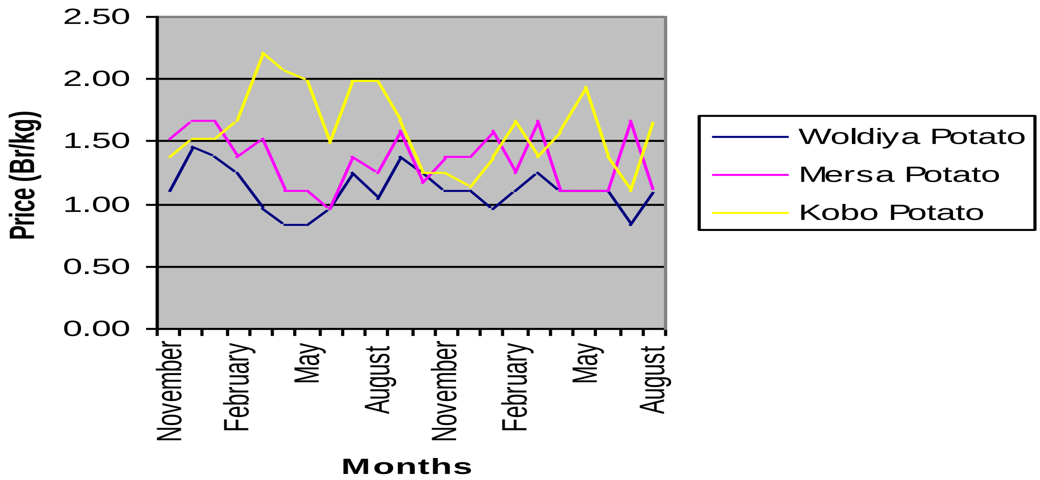

Figure: price of onion in North Wollo

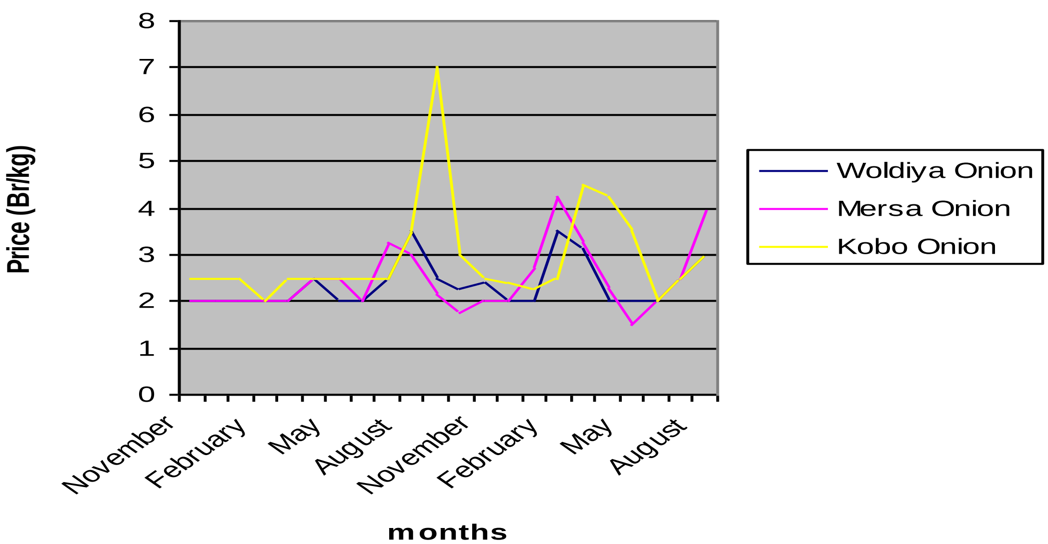

Figure: price of shallot in North Wollo